INVESTIGATION USING THREE DIFFERENT LINT CLEANERS WITH ROLLER-GINNING UPLAND COTTON IN MISSISSIPPI

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Abstract

Roller ginning of upland cotton has been shown to produce fiber with better length properties compared to saw ginning. But if a traditional gin plant from the eastern US wished to install roller gin stands they may also want to use existing saw-type lint cleaners. Data has not been available to show if this combination would compromise the fiber quality. To address this question four cotton cultivars were each ginned at the Cotton Ginning Research Unit in Stoneville, MS with four ginning treatments and the process repeated twice for a total of 32 lots. About 57 kg of lint were packaged from each lot and sent to the Cotton Structure and Quality Research Unit in New Orleans, LA for further processing and spinning. These data showed that the roller gin stand produced fiber about 1 mm, about one staple length, longer than the saw gin stand, at least 0.5 percentage points less short fiber content, and about 20% fewer fiber neps. The roller ginned cotton was cleaned with three different lint cleaners: an Aldrich type cleaner which included a spiked cleaner and an air-jet cleaner, an experimental cleaner including cylinder cleaning and saw cleaning without normal feed works, and a saw lint cleaner normally used with saw ginning. Overall the Aldrich type cleaner following the roller gin stand produced the fiber with the best properties, except for the removal of non-lint. However, the experimental lint cleaner performed as well as the Aldrich type in many respects and cleaned the lint better.

The fiber was processed with mill-type equipment and half was carded and the other half was carded and combed. All fiber was ring spun into Ne 30 yarn. Measurements were made of the sliver at various points of the processing and the yarns were tested. Generally, differences were observed related to cultivar but in this report least squares means were reported related to the ginning processes and means related to cultivar were not reported. Significant differences in HVI and AFIS values were observed related to the ginning process before carding. However, after carding nearly all of the differences of measurements of the sliver were no longer statistically significant. Some difference in card turnout were observed with saw lint cleaning resulting in lower turnout. Lint which had been roller ginned but saw cleaned had a greater percentage of comber noils. Ends down did not vary with ginning treatment. Yarn properties showed small differences in hairiness of carded yarn related to ginning procedures. For yarn neps and thick places for carded fiber the saw ginned lint with saw lint cleaning was the best. Most differences in the combed yarn were not statistically significant. Only for nep count in the yarn from saw cleaned roller ginned cotton was the level different, higher than with the other gin processing methods. The yarn tenacity and breaking force did not vary significantly related to ginning treatment.

Introduction

There are two main types of gin stands which remove cotton fiber from the seed, roller and saw (Gillium et al., 1994). The saw-type gin stand descends from the Eli Whitney design with many improvements and the original design of roller-type has an unknown prehistoric origin. The roller-type gin stand has seen many improvements in the past 50 years but until recently has been much slower than the saw gin stand and thus more expensive to operate (Armijo and Gillum, 2007). Because the roller gin stand was more expensive to operate it was only used on the longer and more valuable extra-long staple cottons, notably Pima cottons. However, after the development of the high-speed roller gin stand (HSRG) it was able to gin as fast per unit width as the saw gin stand and used no more energy per unit of lint produced (Armijo and Gillum, 2007). The HSRG has been used to gin upland cotton which is shorter and less valuable than the extra-long staple cotton. When used with upland cotton the high-speed roller gin produces fiber which is longer, with less short fiber, and fewer neps than when the same cottons are ginned and cleaned with the traditional saw gin stand systems including saw-type lint cleaners (STLC) (Armijo and Gillum, 2007) (Byler and Delhom, 2012) (Hughs et al., 2011).

Certain ginning plants in the west where extra-long staple cotton is grown have batteries of roller gin stands and they process extra-long staple cotton as well as upland cotton. However, roller gin stands are not available for ginning upland cotton in the eastern portion of the cotton belt. To assist in the design of possible installation of HSRG for use in ginning upland cotton in the eastern more humid regions of the US the Cotton Ginning Research Unit of USDA-ARS has tested the use of one of these gin stands with several lint cleaners (Byler and Delhom, 2012). Lint cleaners with spike cleaners in place of the saw-type lint cleaners are often used with an air-jet cleaner. Byler and Delhom (2012) used a cleaner of this type which was a modified Aldrich textile type lint cleaner (ALC) which was produced by Lummus (Lummus Corporation, Savannah, GA). In addition a cleaner developed at the Cotton Ginning Research Unit which included a cylinder cleaner plus a saw cleaner section with no feed works (CSLC). Byler and Delhom (2012) found that the HSRG did less damage to the fiber than the saw gin stand and that the other two types of lint cleaners employed after the HSRG did less damage to the lint than the STLC employed after the saw gin stand.

Gin plants in the eastern portion of the cotton belt have STLC but those are not used with roller ginned cotton. For this study ducting was added so that the lint from the HSRG could be cleaned with the STLC to further clarify the use of lint cleaners after HSRG with eastern cotton. The purpose of this study was to compare the fiber quality produced by the HSRG and traditional saw gin stand including the use of three different lint cleaners after the HSRG to get an indication of the effects of using those lint cleaners after the HSRG.

Materials and Methods

This study was planned to be completed in two parts, the first was the ginning portion performed at the Cotton Ginning Research Unit in Stoneville, MS. The second portion was the spinning portion performed at the Cotton Structure and Quality Research Unit (CSQR) at the Southern Regional Research Center in New Orleans, LA. The ginning was done by quarter bale per cultivar and ginning treatment, about 57 kg of lint. Four quarter bales were ginned using one trailer of cotton of one cultivar, one with the saw gin stand followed by the STLC plus three ginned with the HSRG followed by each of the three lint cleaners, STLC, ALC, and CSLC. The ginning was done with the order of processing varied within the trailers of cotton.

Equipment

All seed cotton was processed the same, after removal from a trailer with air, it was fed to a drying air stream with the burner control set to 66°C (150°F) and cleaned with a cylinder cleaner and stick machine. The seed cotton was then picked up with more air with the burner off and cleaned with a second cylinder machine. One ginning treatment for each cultivar and repetition was ginned with the Continental Double Eagle gin stand (Bajaj Coneagle, LLC, Millbrook, AL), Figure 1,which was 1.422 m (56 in.) wide. Additional treatments from the same source of the same cultivar were ginned with the HSRG (Lummus Corporation, Savannah, GA), Figure 2, followed by one of three lint cleaners. The saw gin stand had an effective ginning width of 1.68 m (66.3 in) and the HSRG had an effective ginning width of 1.01 m (39.8 in).

Figure 3 shows the Continental SixteenD (STLC) and Figure 4 shows the CSLC, an experimental lint cleaner described by (Anthony, 2006). The CSLC included two cleaning portions, lint experienced the cylinder cleaner first and the saw-type cleaner second with no feedworks. There were two cleaning sections in the ALC, Figure 5. In the first the material was processed by the Kirschner beater of the cleaner, Figure 6, followed by an Air-jet cleaner. The active portion of the ALC was 1.346 m (53 in.) wide.

After the bales of lint were complete they were transported to CSQR. Samples of lint were processed for the Advanced Fiber Information System Pro (AFIS) (Uster, Charlotte, N.C.) and for High Volume Instrument (HVI) (Uster, Charlotte, N.C.) measurements for the cotton bale properties. Cotton was processed into carded and combed ring spun yarn to assess the impact of different lint cleaning systems after HSRG on typical Delta-type Upland cottons. Approximately 56 kg (120 lb) of lint was placed into the opening line (standard configuration: Whitin Hopper, Axi-Flo, LVSA, GBRA, RN, RST, Dustex, DK 803 card) for processing at 45 kg/h (100 lb/h).

The card sliver was split during D1 drawing with 18 kg (40 lb) being processed for carded ring spun yarn production and the balance being processed for combed ring spun yarn production. Roving twist was set using a draftometer to optimize roving twist multiple for efficient spinning. Two full doffs of Ne 30 ring spun yarn were produced at 16,000 rpm spindle speed using a 3.8 twist multiple for both carded and combed yarns. A Zinser 321 ring spinning frame with 160 spindles was utilized for all spinning, for a total of 320 bobbins of each yarn construction being produced. Ends down were recorded and are reported per 1000 spindle hours. Some lots had excessive ends down due to hard ends and may not be related to fiber quality, but mill conditions.

Figure 1. Saw type Continental Double Eagle gin stand used in the work.

Figure 2. Lummus high-speed roller gin stand (HSRG) used in the work.

Figure 3. Continental SixteenD saw-type lint cleaner (STLC) used in this work.

Figure 4. Experimental cylinder and saw lint cleaner (CSLC) used in this work.

Figure 5. The entire ALC lint cleaner with the Kirschner beater portion on the right and the air-jet portion on the left of the photograph.

Figure 6. The Kirschner beater portion of the ALC used in the work.

Cotton

Four cotton cultivars were included in this work, Deltapine 1044 (Monsanto Co.), FiberMax 1944 (Bayer CropScience), Stoneville 5458 (Bayer CropScience), and Delta Pine 1321. Table 1 shows the cultivars in the order processed and the ginning equipment used for each treatment.

Table 1. The cotton cultivars and the ginning order and equipment used in the work.

Cotton lot	Cultivar	Gin stand	Lint cleaner
1	DP1044	HSRG	STLC
2	DP1044	HSRG	ALC
3	DP1044	HSRG	CSLC
4	DP1044	Saw	STLC
5	FM1944	Saw	Saw
6	FM1944	HSRG	STLC
7	FM1944	HSRG	CSLC
8	FM1944	HSRG	ALC
9	STV5458	HSRG	ALC
10	STV5458	HSRG	CSLC
11	STV5458	HSRG	STLC
12	STV5458	Saw	STLC
13	DP1321	Saw	Saw
14	DP1321	HSRG	ALC
15	DP1321	HSRG	STLC
16	DP1321	HSRG	CSLC
17	STV5458	HSRG	ALC
18	STV5458	HSRG	STLC
19	STV5458	HSRG	CSLC
20	STV5458	Saw	STLC
21	FM1944	Saw	Saw
22	FM1944	HSRG	STLC
23	FM1944	HSRG	ALC
24	FM1944	HSRG	CSLC
25	DP1044	HSRG	STLC
26	DP1044	HSRG	CSLC
27	DP1044	HSRG	ALC
28	DP1044	Saw	STLC
29	DP1321	Saw	STLC
30	DP1321	HSRG	STLC
31	DP1321	HSRG	ALC
32	DP1321	HSRG	CSLC

Measurements – Samples

Three lint samples were taken between the gin stand and the lint cleaner during processing of each cotton lot for wet basis moisture determination (Shepherd, 1972) and placed in sealed metal cans until measurements were performed. Three additional lint samples were taken during processing of each cotton lot between the gin stand and the lint cleaner for AFIS measurements. From the approximately 57 kg (125 lb) of lint for each cotton lot which were shipped to CSQR for further testing five samples were taken for HVI measurements plus three samples were taken for AFIS measurements. Samples of card sliver, breaker sliver (D1), finisher sliver (D2), combed sliver, finisher combed sliver (D2 combed) were tested on an Uster Tester 5 (UT5) for mass uniformity (CV%) at 46 m/min (50 yd/min) for 2.5 min. AFIS was performed on samples collected at the bale, card mat (after opening/cleaning, but prior to carding), card sliver, breaker sliver (D1), finisher sliver (D2), lapp for combing, combed sliver, comber noil, and finisher combed sliver (D2 combed).

Yarn quality was assessed by selecting 20 bobbins randomly from the 320 bobbins produced for each lot. Each bobbin was subjected to yarn mass uniformity testing on an Uster Tester 4 (UT4) for 366 m/min (400 yd/min) for 2.5 min and tenacity testing on an Uster Tensorapid 4 (UTR4) for 20 breaks per bobbin for a total of 400 breaks per yarn construction. Detailed yarn quality assessments were performed by an Uster Classimat 5 on 40 bobbins of each yarn construction for a total of 91,000 m (100,000 yd) or yarn being analyzed for mass variation, appearance, and foreign matter content. The lots were processed in the opening line in consecutive order, however subsequent processing into roving was randomized within blocks of 3-5 card lots. Spinning was similarly randomized.

Analysis – Statistics
The various data were entered into files and analyzed using SAS version 9.4 (SAS Institute Inc., Cary N.C.) procedure PROC GLM. The model included the cotton cultivar and the ginning treatment (one of four). The least squares means were calculated and the lsmeans statement was used in PROC GLM to determine which means were significantly different. There were two complete repetitions of the four cultivars which each had four ginning treatments for a total of 32 ginning lots. For each of these treatments multiple separate samples were taken, between the gin stand and lint cleaner while the ginning tests were taking place and from the lint sent to CSQR for all subsequent tests.

Results and Discussion

Lint Moisture Content
The mean of the lint moisture contents were calculated and are shown in Table 2.

Table 2. Least squares means of moisture content of each cultivar included in the test.

Cultivar	DP1044	DP1321	FM1944	STV5458
Moisture content	6.4 a*	5.5 b	5.9 ab	5.4 b

*Means with the same letter within a row were not significantly different at the 0.05 level

These moisture contents were within the range observed at commercial gins but were higher than normally seen. Based on this observation the fiber strength would be expected to be somewhat greater than typically seen at gins with somewhat lower short fiber levels and less susceptibility to damage due to ginning and lint cleaning.

Fiber Quality Data
This test included four cotton cultivars each subjected to four ginning treatments and repeated twice. For differences in AFIS data for samples collected before the lint cleaner both cultivar and treatment, in this case only the gin stand, were statistically significant and there was no interaction between these factors. From Table 3 the roller ginned lint had better properties than the saw ginned fiber except for the foreign matter content for each cultivar with longer fiber and less short fiber and neps. The fiber length was about 1 mm (one staple length) longer with about 20% fewer neps and at least 0.5 percentage points less short fiber when ginned with the roller gin stand.

Table 3. Least squares means of selected AFIS measurements before the lint cleaner.

Cultivar	DP1044		DP1321		FM1944		STV5458	
Gin stand	Roller	Saw	Roller	Saw	Roller	Saw	Roller	Saw
Mean length by weight (mm)	27.1 d*	26.5 e	28.8 b	28.1 c	29.5 a	28.6 bc	27.9 c	26.6 d
Upper quartile length by weight (mm)	32.6 c	32.3 c	33.8 b	33.4 b	35.6 a	35.2 a	33.8 b	32.8 c
Short fiber content (percent)	8.0 b	8.5 ab	5.0 d	5.7 cd	6.3 c	7.2 b	7.6 b	9.1 a
Visible foreign matter (percent)	2.14 d	2.45 bcd	2.38 cd	2.52 bcd	2.65 bc	3.74 a	2.35 cd	3.30 ab
Nep count (per g)	143 cd	177 ab	144 cd	160 bc	133 d	172 abc	159 bc	193 a

*Means with the same letter within a row were not significantly different at the 0.05 level

Means of several measurements of lint from the bale by cultivar and two ginning sequences are shown in Table 4. The two ginning sequences compare ginning with traditional saw gin stand and lint cleaner with roller ginning followed by the ALC. For a given cultivar the fiber was longer with less short fiber and fewer neps using the roller ginning sequence than the traditional saw sequence. However the foreign matter content was somewhat higher with the roller ginning sequence. The HVI fiber strength was not different by ginning sequence but did vary due to cultivar. The micronaire was higher when the lint was roller ginned.

Table 4. Least squares means of selected AFIS and HVI measurements after a lint cleaner.

Cultivar	DP1044		DP1321		FM1944		STV5458	
Gin stand and lint cleaner	Roller and ALC	Saw and STLC	Roller and ALC	Saw and STLC	Roller and ALC	Saw and STLC	Roller and ALC	Saw and STLC
Mean length by weight (mm)	26.4 cd*	25.4 e	27.4 b	26.8 bc	28.3 a	27.4 b	26.4 cd	25.7 de
Upper quartile length by weight (mm)	31.1 b	30.5 c	31.5 b	31.5 b	33.8 a	33.3 a	31.8 b	31.2 b
Short fiber content (percent)	6.3 bc	8.3 a	4.0 e	5.1 d	5.4 cd	7.2 b	7.2 b	8.3 a
Visible foreign matter (percent)	2.3 ab	1.2 c	2.6 a	1.5 bc	1.7 abc	1.4 bc	1.8 abc	1.4 bc
Nep count (per g)	139 c	227 a	126 c	191 ab	108 c	180 b	139 c	222 a
HVI fiber strength (g/Tex)	29.40 e	30.05 de	30.90 cd	31.45 bcd	33.00 a	32.65 ab	31.20 cd	31.40 cd
Micronaire	5.30 a	4.95 c	4.95 c	4.70 d	5.05 bc	4.90 c	5.20 ab	4.90 c

*Means with the same letter within a row were not significantly different at the 0.05 level

Table 5 shows the least squares means of selected AFIS measurements of samples taken after lint cleaning. Roller ginning followed by the ALC produced the fiber with the best properties with longer fiber and less short fiber and fewer neps. Only the visible foreign matter measurement was of lower quality than the other gin treatments. In many cases the roller ginning followed by the ALC produced fiber with properties not statistically better than at least one of the alternative lint cleaners following roller ginning. In particular the CSLC cleaned better than the ALC but produced fiber which was not significantly lower in quality. Use of the STLC resulted in lint with more short fiber and more neps but with less visible foreign matter. The market value of the cotton will be determined by measurements similar to those in Table 5. Some of the advantage from roller ginning upland cotton was lost when the saw-type lint cleaner was used, including fiber length, short fiber content and nep content. But the lint was cleaner following the STLC compared to the ALC, which also can be important to pricing.

Table 5. Least squares means across cultivars of selected AFIS measurements, lint in the bale.

Gin stand	Lint cleaner	Mean length by weight (mm)	Upper quartile length by weight (mm)	Short fiber content (percent)	Visible foreign matter (percent)	Nep count (per g)
Roller	ALC	27.2 b*	32.2 a	5.66 b	2.36 a	131 c
Roller	CSLC	27.3 b	32.3 a	5.50 b	1.40 b	147 bc
Roller	Saw	26.8 c	32.1 a	6.83 a	1.77 b	161 bc
Saw	Saw	26.5 c	31.7 b	6.98 a	1.50 b	199 a

*Means with the same letter within a column were not significantly different at the 0.05 level

Analysis of the upper half mean measurement in the HVI data, Table 6, showed that the roller gin followed by the ALC produced the longest fiber, although the length after the CSLC was nearly as long. Use of the saw lint cleaner resulted in fiber which was somewhat but statistically significantly shorter. The HVI uniformity index and the short fiber content were two indicators of the short fiber content and the data showed that the ALC and CSLC produced lint with no significant difference while the STLC resulted in fiber with more short fiber and lower uniformity index. The non-lint area HVI measurement showed that the ALC produced the least cleaning and the CSLC and STLC performed equally well at removing non-lint. The micronaire levels of these cottons were high, they were lowest for saw ginned cotton followed by saw lint cleaning and highest for roller ginned cotton followed by the ALC lint cleaner. Somewhat higher micronaire for roller ginned cotton than saw ginned cotton has been observed before (Byler and Delhom, 2012) but others have not observed this difference (Armijo and Gillum, 2007). Use of the STLC reduced the HVI fiber length and short fiber content while reducing the uniformity indes, all factors which reduce the advantage of using the roller gin stand to process upland cotton but also produced cleaner lint.

Table 6. Least squares means across cultivars of selected HVI measurements.

Gin stand	Lint cleaner	Upper half mean length (mm)	Micronaire	Uniformity index, percent	Short fiber content (percent)	Non-lint area (percent)	Fiber strength (g/tex)
Roller	ALC	30.9 a*	5.1 a	84.3 a	6.47 c	0.74 a	31.1 a
Roller	CSLC	30.5 b	5.0 b	83.9 ab	6.85 c	0.48 b	31.5 a
Roller	Saw	30.3 b	5.0 b	83.6 b	7.28 b	0.48 b	31.5 a
Saw	Saw	29.8 c	4.9 c	82.8 c	8.17 a	0.41 b	31.4 a

*Means with the same letter within a column were not significantly different at the 0.05 level

The means of the AFIS fiber length calculated by weight data for the fiber being spun from the carded material are shown in Table 7. The greatest variation was due to the cultivar but the means by gin treatment and location in the processing line are shown. For the lint in the bale the roller ginned and lint cleaned with the ALC or CSLC had better length and the saw ginned with saw lint clener had the lowest length. The means varied for the lint in the bale, but after mill processing the differences were much smaller and were not statistically significant.

Table 7. Least squares means of AFIS length by weight (mm) at different points in the carding line by gin treatment.

Gin stand	Lint cleaner	Bale	Card mat	Card sliver	D1 sliver	D2 sliver
Roller	ALC	27.1 a*	26.5 a	25.8 a	26.3 a	26.2 a
Roller	CSLC	27.1 a	26.5 a	26.0 a	26.1 a	26.1 a
Roller	Saw	26.7 b	26.1 a	26.3 a	26.0 a	25.7 a
Saw	Saw	26.3 c	26.1 a	25.7 a	25.8 a	25.7 a

*Means with the same letter within a column were not significantly different at the 0.05 level

For the means of the AFIS fiber length by weight measurements made with the fiber used to make the combed yarn, Table 8, there were no differences which were significantly different. For the noils, the material removed during combing, the fiber was significantly shorter for the material saw ginned with the saw lint cleaner than the fiber which was roller ginned and especially roller ginned with saw lint cleaning.

Table 8. Least squares means of AFIS length by weight (mm) at different points in the combing line by gin treatment.

Gin stand	Lint cleaner	Lapp	Comber sliver	D2 Comber sliver	Noil
Roller	ALC	26.4 a*	26.9 a	26.7 a	13.1 b
Roller	CSLC	26.4 a	26.7 a	26.7 a	13.1 b
Roller	Saw	25.7 a	26.5 a	26.6 a	14.2 a
Saw	Saw	26.0 a	26.7 a	26.6 a	12.9 b

*Means with the same letter within a column were not significantly different at the 0.05 level

Table 9 shows the means of measurement of the AFIS short fiber content by weight for the fiber used in spinning the carded yarn. The levels in the bale samples were significantly different with the roller ginned with the ALC or CSLC having the lowest levels and the saw cleaned either roller ginned or saw ginned significantly higher. However, after mill-type processing the differences were no longer statistically significant, although the numbers for the fiber from saw lint cleaning were larger, but without statistically significant differences.

Table 9. Least squares means across cultivars of AFIS short fiber content by weight (%) at different points in the carding line by gin treatment.

Gin stand	Lint cleaner	Bale	Card mat	Card sliver	D1 sliver	D2 sliver
Roller	ALC	5.7 c *	7.0 a	8.1 a	7.6 a	8.2 a
Roller	CSLC	6.0 b	6.7 a	7.8 a	8.3 a	8.5 a
Roller	Saw	6.9 a	7.7 a	8.7 a	8.3 a	9.2 a
Saw	Saw	7.2 a	7.7 a	8.4 a	8.6 a	9.1 a

*Means with the same letter within a column were not significantly different at the 0.05 level

Table 10 shows the means of measurement of the AFIS short fiber content by weight for the fiber used in spinning the combed yarn. None of the measured fiber properties were significantly different from each other due to ginning procedure. The short fiber content of the noils from the saw cleaned roller ginned lint as lower than with the other ginning treatments.

Table 10. Least squares means across cultivars of AFIS short fiber content by weight (%) at different points in the combing line by gin treatment.

Gin stand	Lint cleaner	Lapp	Comb	D2Comb	Noil
Roller	ALC	7.6 a*	5.3 a	5.7 a	59.2 a
Roller	CSLC	7.9 a	5.6 a	5.8 a	58.7 a
Roller	Saw	9.3 a	5.9 a	6.0 a	55.1 b
Saw	Saw	8.6 a	5.5 a	5.8 a	59.8 a

*Means with the same letter within a column were not significantly different at the 0.05 level

Table 11 shows the means across cultivars of measurement of the AFIS visible foreign matter content by weight for the fiber used in spinning the carded yarn. There were significant differences by ginning treatment of the fiber in the bale with the roller ginned fiber and the ALC cleaner having the highest foreign matter level and the saw ginned lint followed by the saw lint cleaner having the lowest levels. However, before carding most of the differences were no longer statistically significant and after carding none of the means were statistically different.

Table 11. Least squares means of AFIS visible foreign matter (%) at different points in the carding line by gin treatment.

Gin stand	Lint cleaner	Bale	Card mat	Card sliver	D1 card sliver	D2 card sliver
Roller	ALC	2.11 a*	1.10 a	0.03 a	0.04 a	0.04 a
Roller	CSLC	1.45 b	0.68 b	0.08 a	0.05 a	0.06 a
Roller	Saw	1.94 a	1.01 a	0.02 a	0.04 a	0.03 a
Saw	Saw	1.35 b	0.74 b	0.02 a	0.02 a	0.02 a

*Means with the same letter within a column were not significantly different at the 0.05 level

Table 12 shows the means of measurement of the AFIS visible foreign matter content by weight for the fiber used in spinning the combed yarn. None of the ginning treatments resulted in significant differences in the measured levels after this level of mill processing. Apparently the card removed enough of the non-lint to reduce the differences to a level where whatever differences which may have remained were not measurable.

Table 12. Least squares means across cultivars of AFIS visible foreign matter (%) content at different points in the combing line by gin treatment.

Gin stand	Lint cleaner	Lapp	Comber sliver	D2 Comber sliver	Noils
Roller	ALC	0.03 a	0.01 a	0.01 a	0.29 a
Roller	CSLC	0.04 a	0.09 a	0.09 a	0.22 a
Roller	Saw	0.03 a	0.03 a	0.04 a	0.27 a
Saw	Saw	0.05 a	0.07 a	0.07 a	0.15 a

*Means with the same letter within a column were not significantly different at the 0.05 level

Mill data

Table 13 show the means of several measurements related to mill efficiency. The card turnout did not vary by cultivar but varied by ginning treatment. The best turnout was for the fiber from roller ginning followed by the CSLC. The lowest turnout was for the saw ginned cotton followed by saw lint cleaning. The best (lowest) percentage of comber noils, was for the saw ginned and saw cleaned fiber but only the roller ginned cotton followed by the saw lint cleaner was statistically higher. Cultivar was the most significant factor affecting comber noils. The best (lowest) ends down for carded and combed cotton spinning was for the roller ginned fiber followed by the ALC but there were no statistical differences in the ends down within each spinning method. Ends down for carded and combed fiber only varied by cultivar, not the ginning treatment.

Table 13. Least squares means of certain measurements related to mill efficiency calculated by ginning treatment.

Gin stand	Lint cleaner	Card Turnout	Comber noils (%)	Ends down for carded fiber /khr	Ends down for combed fiber /khr
Roller	ALC	87.0 b*	13.34 b	135.4 a	33.9 a
Roller	CSLC	89.1 a	13.45 b	200.5 a	46.1 a
Roller	Saw	87.5 ab	14.09 a	263.5 a	37.1 a
Saw	Saw	86.5 b	13.09 b	187.2 a	37.5 a

*Means within each type measurement followed by the same letter were not significantly different, $P<0.05$.

Yarn data

Selected results of testing the yarn are shown in Tables 14 and 15. Table 14 shows data for the yarn made from carded fiber and all of these measurements varied with the cultivar and the ginning treatment with no interaction. Hairiness varied most strongly by cotton cultivar but varied slightly with the ginning treatment. Yarn neps varied with cultivar but also varied with ginning treatment with the roller ginned fiber followed with the CSLC having the highest nep level and the saw ginned fiber followed by the saw lint cleaner the lowest nep level. The effects of the ginning treatment on thick places, thin places, and yarn CV were similar with the saw ginned lint followed by the saw lint cleaner having the best (lowest) levels. The yarn tenacity and breaking force were similar to each other and varied mostly with the cultivar. They also varied by ginning treatment with the roller ginned fiber followed by the saw lint cleaner slightly worse (lower) but the other treatments resulting in levels which were not different, statistically.

Table 14. Least squares means across cultivars of results of testing the yarn spun from carded fiber.

Gin stand	Lint cleaner	Hairiness	Neps >200%	Thick >50%	Thin <50%	CV (%)	Tenacity	Breaking force
Roller	ALC	5.18 ab*	430.0 b	866.3 b	111.0 ab	18.9 b	14.10 ab	2.78 ab
Roller	CSLC	5.15 b	453.6 ab	915.4 b	124.0 a	19.1 ab	14.29 ab	2.81 ab
Roller	Saw	5.29 a	476.2 a	995.1 a	124.9 a	19.4 ab	13.92 b	2.74 b
Saw	Saw	5.22 ab	223.3 c	758.6 c	91.6 b	18.5 c	14.42 a	2.84 a

*Means within each type measurement followed by the same letter were not significantly different, $P<0.05$.

The means of measurements of yarn spun from combed fiber are shown in Table 15. The hairiness measurement did not vary by ginning treatment but only by cultivar. The Neps <200% measurement varied by cultivar and ginning treatment. The best ginning treatment related to Neps was the saw ginning with saw lint cleaning. The other measurements shown in Table 15 did not vary significantly by ginning treatment. Armijo et al. (2013) found that roller ginning resulted in fewer fiber neps but more yarn neps as was found in this study, and proposed that the higher trash levels in the roller ginned fiber may result in the higher yarn nep level. This study does not strongly support that idea because the roller ginned lint with the non-ALC cleaners had relatively low non-lint levels but also higher yarn neps than the saw-ginned saw-cleaned lint.

Table 15. Least squares means of certain measurements of testing the yarn from combed fiber.

Gin stand	Lint cleaner	Hairiness	Neps >200%	Thick >50%	Thin <50%	CV (%)	Tenacity	Breaking force
Roller	ALC	4.75 a*	47.3 b	160.5 a	14.3 a	15.1 a	15.6 a	3.07 a
Roller	CSLC	4.88 a	49.5 b	168.1 a	14.1 a	15.1 a	15.4 a	3.04 a
Roller	Saw	4.88 a	54.3 a	180.4 a	14.5 a	15.2 a	15.5 a	3.06 a
Saw	Saw	4.87 a	37.1 c	162.9 a	14.5 a	15.1 a	15.6 a	3.08 a

*Means with the same letter within a column were not significantly different at the 0.05 level

Summary

Four cotton cultivars were each ginned at the Cotton Ginning Research Unit with four ginning treatments and the process repeated twice for a total of 32 treatments. About 57 kg of lint were packaged from each lot and sent to the Cotton Quality Research Unit for further processing and spinning. These data showed that the roller gin stand produced fiber of higher quality than the saw gin stand related to fiber length, short fiber content, and fiber neps. The roller ginned cotton was cleaned with three different lint cleaners: an Aldrich type cleaner which included a spiked cleaner and an air-jet cleaner, an experimental cleaner including cylinder cleaning and saw cleaner without normal feedworks, and a saw lint cleaner normally used with saw ginning. Overall the Aldrich type cleaner following the roller gin stand produced the fiber with the best properties, except for the removal of non-lint. However, the experimental lint cleaner performed as well as the Aldrich type in many respects and removed more non-lint. The use of the saw-type lint cleaner after the roller gin stand produced lint of somewhat lower quality, except for cleanliness. For the producer the best quality lint was produced with the roller gin followed by the Aldrich type cleaner and the use of the saw-type cleaner reduced the properties somewhat. In comparing the use of the Aldrich type and saw-type lint cleaner behind the roller gin stand there was a tradeoff between maximum fiber quality and cleanliness of the fiber. Cotton mills have excellent cleaning capabilities and the trash levels were not so high with the Aldrich cleaner, so for the industry as a whole it would seem best to maintain as much of the fiber quality as possible at the gin and let the mills deal with slightly higher non-lint levels.

Half the lint was carded and the other half carded and combed. The fiber was ring spun into Ne 30 yarn. The sliver and yarn were tested. There were few significant differences in the sliver or yarn after carding and none after combing. However, there were a few differences in the comber noils. The percentage of the comber noils was highest for the roller ginned and saw cleaned lint. There were no statistically significant differences in the ends down for either spinning method.

Disclaimer

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the U. S. Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available.

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